Module #6 Cold Mass Assembly Outside of the Clean Room

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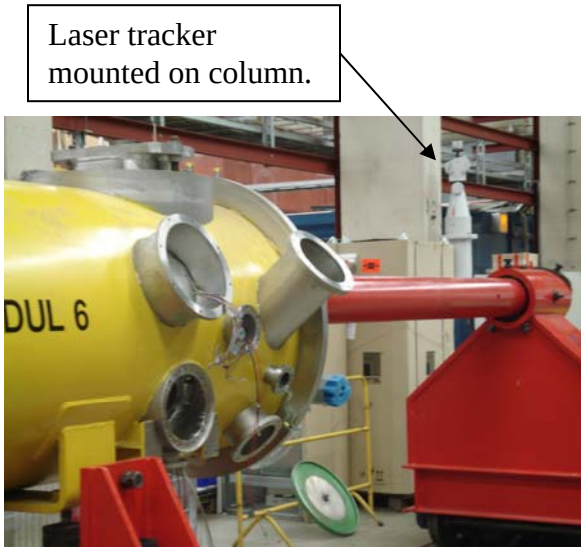
Week-V

Day 17 - June 12, 2006

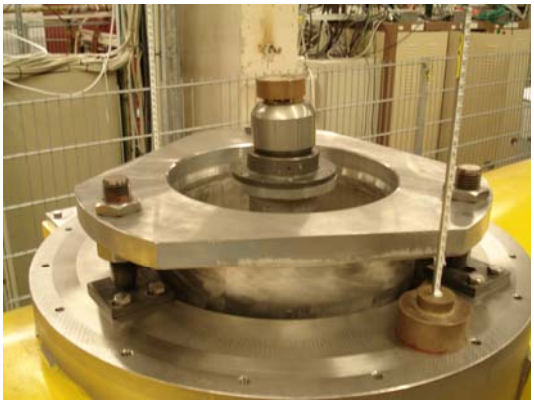
With cold mass and vacuum vessel assembled and course alignment complete, today's task was final alignment of cold mass to vacuum vessel. The alignment crew arrived at 9am and finished by 3pm. They set up both a laser tracker and a traditional optical (theodolite) measurement device. Surveyors are learning to use laser tracker so both instruments used.



Optical measurement used brass survey mounts with 30cm scales installed. Some mounts are flat-bottomed and sat atop the vacuum vessel's cold mass mount flanges. The other optical survey mounts include a spherically-shaped feature for installation into Taylor-Hobson cup mounts installed on both the vessel and the cold mass support posts. One pair of tooling balls (~20mm diameter) was installed on the horizontal survey bracket at each of the cold mass support flanges.

Alignment process:

1. Survey elevation of cold mass mounting flanges on top of vessel with respect to level earth.

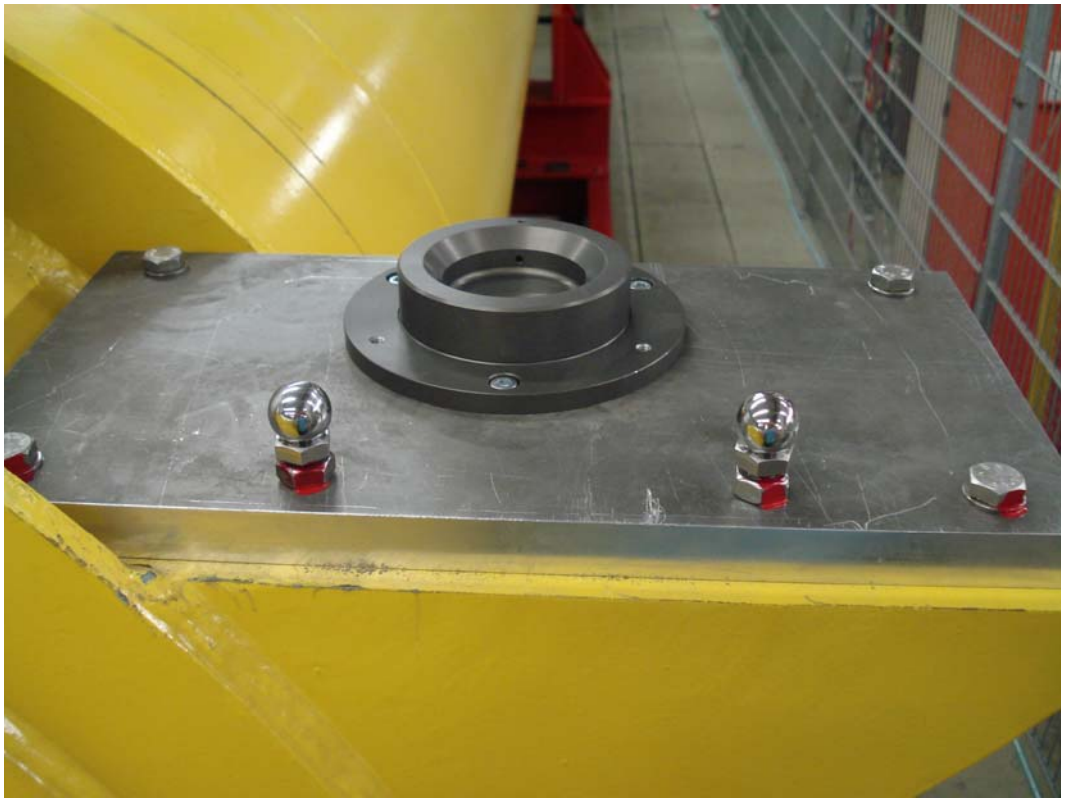



2. Level these surfaces (the cryomodule) by adjusting screw jack feet of vacuum vessel.

3. Using hand-held level, level tooling ball pair until parallel with cold mass mounting flange at each of the three post positions. Balls leveled by adjusting nuts on stem. (These tooling balls will be referenced for setting cryomodule rotation about beam (Z-axis) when installed in the tunnel.)


4. Align cold mass vertically (Y-direction) to vessel. Datum is top alignment flanges. Goal is to align cavity centerline, when cold, to match elevation of coupler flanges on vacuum vessel. Simultaneously maintain overall straightness of cavity string by matching dimensions from cavity center to mounting posts established during alignment on overhead fixture (see Week III, Day 8 – May 28, 2006).

5. Align cold mass horizontally (X-direction) to vessel, again simultaneously maintaining cavity straightness using survey data collected while on overhead fixture.

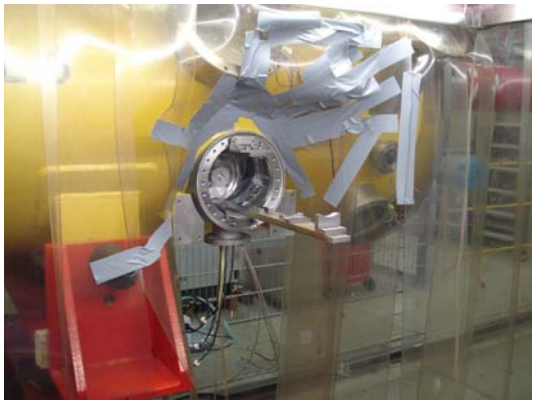


Day 18 - June 13, 2006

Coupler installation started today. There are a total of eight to be installed with the nominal schedule of two per day, requiring two technicians. Installation of a single coupler warm end assembly needs to be completed before the end of the day to limit exposure of the coupler to atmospheric contamination. 'Coupler installation' is only installation of the warm end of the coupler and waveguide since the cold portion is already installed as part of the cold mass assembly. Couplers are installed starting at position-8 at the quadrupole end of the cold mass. (Cavity string is not under vacuum but instead back-filled with argon. Installing couplers with the cavity evacuated complicates assembly and tooling because bellows in cold end assembly would tend to compress and therefore would require external restraint. Additionally, with cavity evacuated, vacuum would be monitored. Periodic spikes in pressure would inevitably be measured, causing consternation, discussion, and debate as to whether something was damaged.)

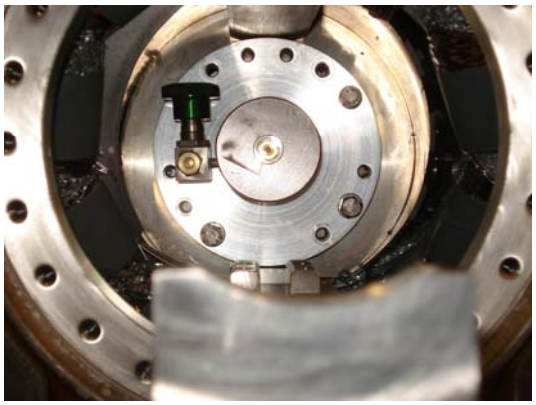
Outside surfaces of the vacuum vessel in the region of the coupler port wiped to remove dust. Mobile clean room placed around coupler port. Clean room drapes taped to vessel to loosely 'seal' to the vessel. Relevant drawings and assembly procedures posted. All hand tools, installation fixtures, and hardware staged in or near clean room for easy access.

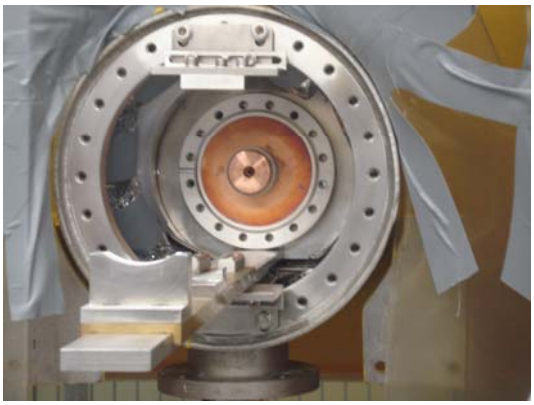
Coupler installation tooling mounted to coupler flange on vessel (either before or after clean room is positioned).

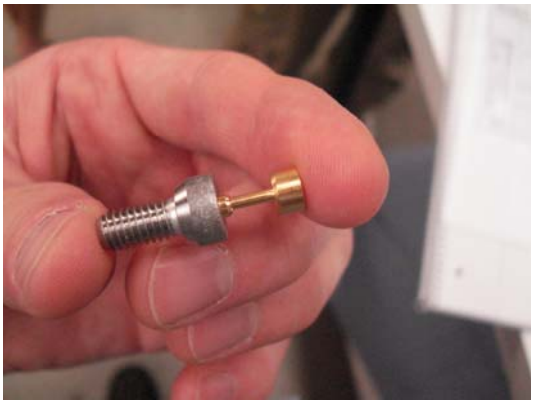


Threaded rods providing temporary stiffening to cold end assembly removed. Technicians put on glean room gowns, hoods, face masks, and gloves when interior volume of coupler open (where flanges covered with plastic caps = open).

With long attachment on socket wrench, removed screws holding protective cap from cold end assembly. This cap is sealed to 80K flange with elastomer CF seal. (Cap was pumped and back-filled with nitrogen when cap was installed.) There are typically (4) fasteners holding cap in place. Bottom two fasteners are removed first. Top two are loosened, and then cap is held in one hand while the remaining two fasteners are removed. It is important not to allow protective cap to fall or even contact the cold window.







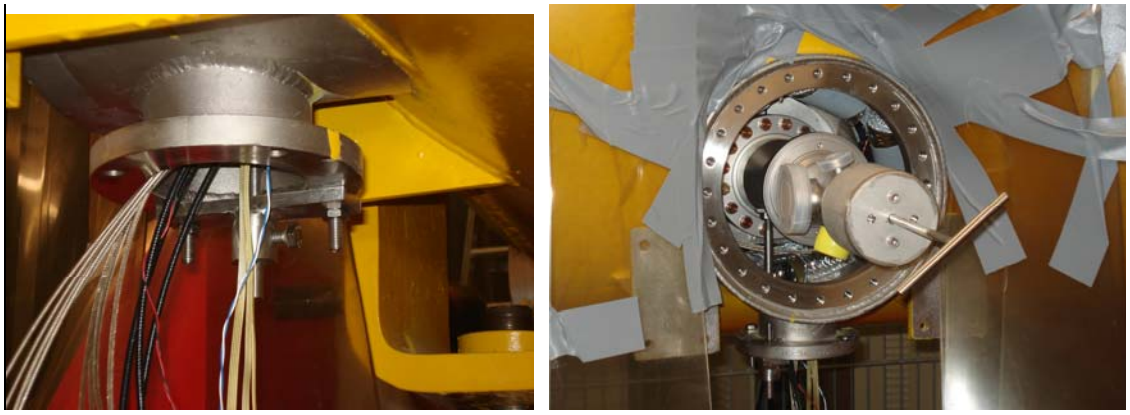
Electrical contact plunger removed from antenna. This is a spring-loaded plunger that makes contact with the BNC connector on the cold window protective cap. It is used for RF test of coupler/cavity. (W-D Moeller says it is a commercial item used in industry to test PC boards.)

Wiped knife edge on 80K flange on cold end assembly. CF gasket installed into 80K flange on cold end assembly. This gasket has edges on inside diameter rounded to eliminate sharps in RF volume. Gasket deformed out of round by striking it on edge on a hard surface so it snaps into the flange and holds itself in position.

Warm end coupler assembly removed from protective box (stored under nitrogen). Long hex driver is inserted through back of the doorknob down the center of the inner antenna and engaged with the captive screw at the end of the antenna. This screw joins the cold end and warm end antennas. As stored, screw holds warm end assembly to a protective blank flange attached at 80K end. Screw loosened, disconnecting warm end assembly from flange blank. Wiped knife edge on 80K flange on warm end assembly.

Warm end coupler staged onto installation tooling and slid into position. Captive screw tightened, joining inner conductors of cold end and warm end assemblies. Couplers joined at the 80K flange with silicon bronze fasteners and tightened (without a torque wrench). Captive screw joining warm end and cold antennas was again tightened.

Temporary coupler support installed through instrumentation port below coupler. Installation tooling removed. Coupler hangs, held only by temporary support from below. It's bouncy when cantilevered like this. E-pickup cable attached and routed down through instrumentation port.

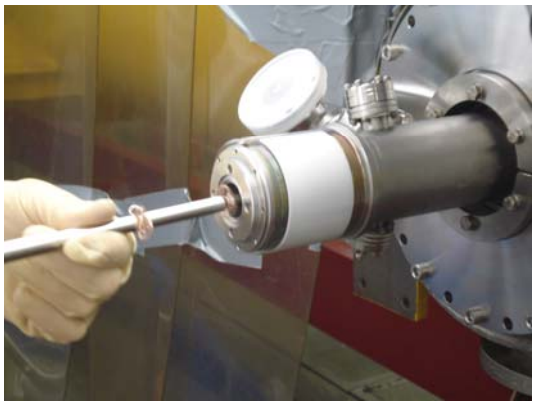


(10) layers of MLI wrapped around warm-end assembly, then (10) layers from 80K shield dressed down, and repeat 2x's more. This creates overlap between those layers around the outer conductor and those on the 80K shield. All together, installing super-insulation took about 1.5 to 2hours.

Vessel flange installed, sealing coupler port. Proper rotation of this flange allows easy installation of all fasteners at the split ring clamp. Otherwise an interference results when trying to install fasteners near coupler's vacuum port.

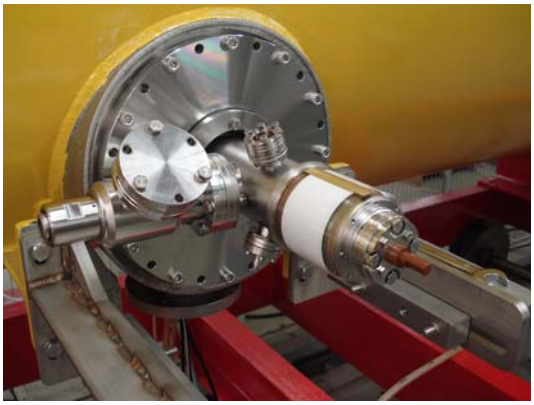
1.33"CF window and e-pickup installed. These cannot be installed before warm end assembly is connected to vessel because they would interfere with installation of vessel flange over the coupler.

Protective cap removed from warm window. Tuning rod installed through back of doorknob. The rod end keys into a slot in the antenna and is captured with a 90° rotation. Springs wrapped around tuning rod are there for cancellation of possible reflection.

A handle is temporarily used on back of doorknob to react the torque applied when tightening fasteners so strain isn't imparted through ceramic warm window. Tuning rod secured to back of doorknob with CF seal. Tuning rod extension and flange installed on tuning rod. Protective cap installed over warm window.


Right angle valve installed and oriented correctly for attachment to vacuum manifold. All CF flanges leak checked. Work stopped for the day when a possible small leak was found. Leak detector showed only a minor response. To leak check 80K flange, helium is blown up through instrumentation port. This is cumbersome but current assembly scheme has only plastic protective caps over coupler ports while inside of vessel is accessible through coupler port. Not until the coupler port is closed off, are all ports on the warm end assembly sealed, allowing the leak check.



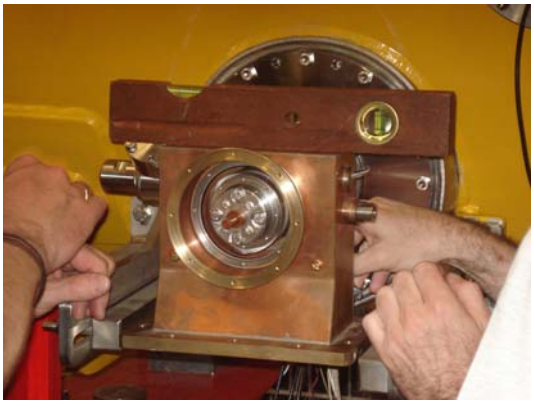
Day 19 - June 14, 2006

Mobile clean room moved to coupler port #7. Repeated steps as recorded from Day 18 and then continued as below for coupler installation.

Finish Installation of Coupler at Port-8

At port #8 coupler (continuation from yesterday), finished leak check. Conclusion was that slight leak reading from yesterday was result of doing leak check inside the clean room tent. Excessive background helium was getting to leak detector by diffusing through O-rings on leak detector flex hoses. Right angle valve closed and leak detector removed. Couplers are left under vacuum.

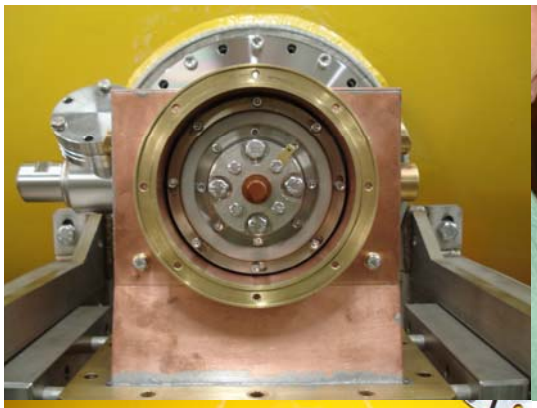
Waveguide mounting brackets loosely attached to the side of the vacuum vessel. Protective cap removed from ceramic while protective Mylar sleeve left in place. Aluminum foil wrapped around flange at vessel side of warm window. This foil was not part of original design but tolerance of assembly can leave a gap in the mating flange between the waveguide and warm end assembly that can be a source of sparks. Aluminum foil prevents this. W-D says it will be fixed in next design iteration.

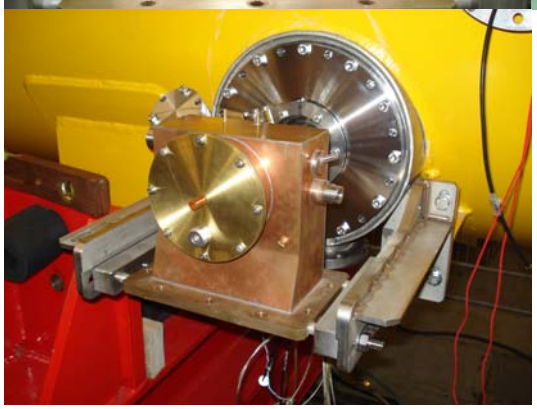


Waveguide installed over warm window by hand (i.e. no installation tooling). Split ring installed on vessel side of waveguide to secure it to warm end assembly. Waveguide leveled with bubble level as nuts were tightened on backside. Protective Mylar sleeve removed from warm window. Waveguide to doorknob restraining ring assembly installed.

Waveguide connected to vessel support brackets and support brackets firmly tightened to vessel.

Wire for bias voltage in waveguide connected under screw head in tuning rod flange. Waveguide cover installed.

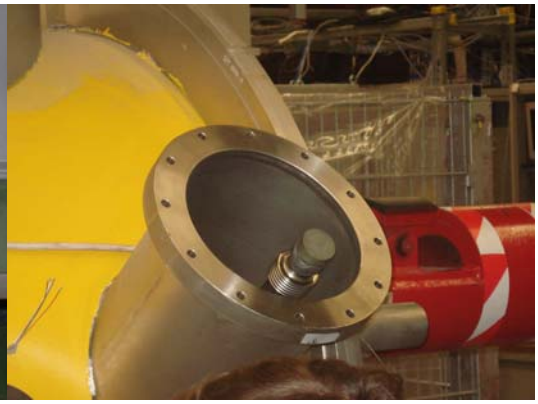




Warm end assembly of coupler-6 also installed today. Pumped down overnight for leak check in morning.

Install Quadrupole Superconducting Leads

At quadrupole superconducting lead feed-through, connection tube installed with rotatable 2.75”CF flange at one end and bellows at the other. This is the tube that the superconducting leads feed through from outside the vessel to the magnet. Leaked checked this CF joint by first plugging all holes at end of cryomodule with machined plugs and sealant similar to Apiezon Q-wax. Superconducting leads installed through flange.



Day 20 - June 15, 2006

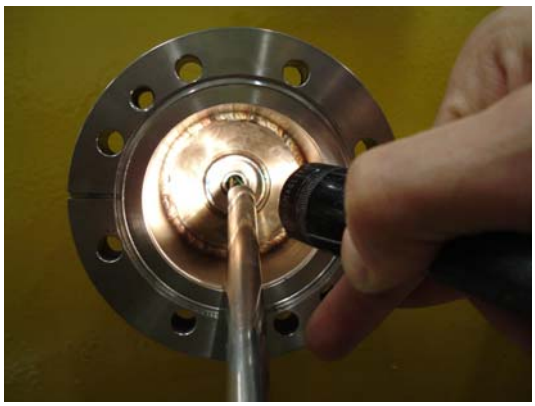
Coupler Installation

Coupler-5 warm end assembly installation started as recorded above but a silicon bronze fastener at 80K flange broke during tightening. These fasteners are re-used and they will break from time to time. Normally they would use virgin fasteners for cryomodule installation but they didn't have enough on hand. Warm end installation time to installation of super-insulation is 1hr. Super-insulation time is 1.5hr. Warm end installation finished by lunch.

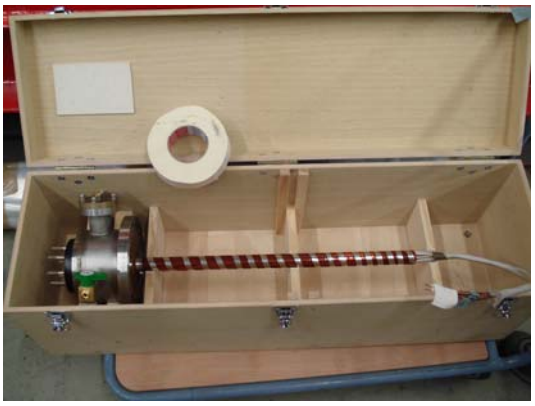
Coupler-4 coupler warm end assembly installed after lunch.

Superconducting Leads

TIG welded superconducting leads feed-through stub to vessel flange. Also welded small ~0.5" tube stub below it at "potential" flange (low power supply to magnet). Leak checked these welds.



Superconducting leads inserted and sealed to vessel flange with indium seal. (Sometimes the heater fails so this flange can become very cold. Indium is the best material to maintain the seal.) The indium seal was leak checked.

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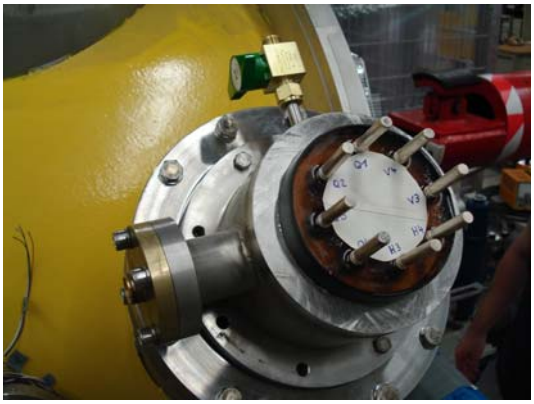


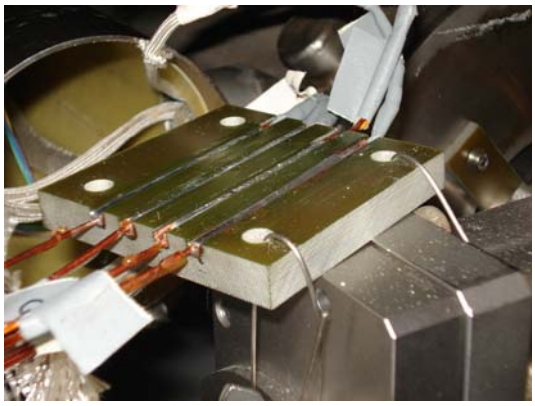
Day 21 - June 16, 2006

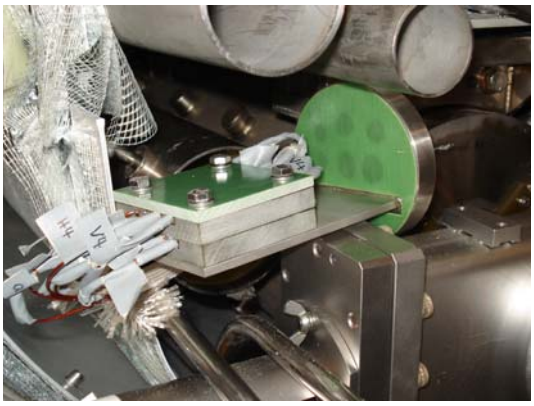
Coupler Installation

Clean room moved back to coupler-5 port. The tuning rod installed is of an older version. Its tuning range is smaller than the new style and had to be replaced. Warm end assembly at coupler port 3 and port 2 installed. Waveguide at port 5 and 4 installed.

Superconducting Leads

Leads tested for continuity and proper labeling. Leads soldered together inside G10 board with copper lined grooves. Copper is a foil. Leads sealed into "wiring box" with plug prepared with welding groove. This weld and final leak check will be completed Monday, June 19.





Final warm end assembly at coupler port 1 is to be installed Monday, June 19 as well as waveguides at ports 3, 2, and 1. This was not observed by Fermi personnel.